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Field and aviary evaluation of low-level application rates of methiocarb for reducing bird damage to blueberries

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Abstract In the United States, Mesurol 75% wettable powder (active ingredient methiocarb) was formerly registered as a bird repellent on blueberries and cherries. In part because of concerns over residue levels, this chemical is no longer registered for use on fruit. One approach to reducing residues is to lower the application rate. Methiocarb was evaluated on blueberries in an aviary trial at application rates of 0.6, 1.1 and 1.6 kg ha^{-1} and in the field at 1.1 and 1.6 kg ha^{-1}. In the aviary trial, individually caged cedar waxwings (*Bombycilla cedrorum*) were not repelled by the application at 0.6 kg ha^{-1}, but consumption of blueberries was reduced by 60% with the treatments at 1.1 and 1.6 kg ha^{-1}. In the field trial at 1.1 kg ha^{-1}, bird damage to blueberries in the treated plot was 57%, compared with 29.5% on the untreated plot. In the field trial at 1.6 kg ha^{-1}, blueberry loss at 7 and 14 days post-treatment was 59% and 85% on the treated unit and 65% and 85% on the control, respectively. Methiocarb residues on blueberries decreased from 8.56 p.p.m. at 1 day post-treatment to 1.28 p.p.m. at 14 days post-treatment. The results of these trials (a) suggest that reduced methiocarb applications do not effectively control bird damage to blueberries and (b) do not support further pursuit of a new Mesurol registration for this use.

Keywords Bird repellent; blueberries; cedar waxwing; crop damage; methiocarb

Introduction

Migratory birds cause substantial damage to ripening fruit crops in the United States (Mott and Stone, 1973; Crase *et al.*, 1976). In a 1989 survey of bird damage to blueberries in the United States and British Columbia, growers estimated that 10% of the blueberry crop was damaged by birds (Avery, Nelson and Cone, 1992). When extrapolated to the 1989 US blueberry production [158×10^6 lb ($\approx 71.1 \times 10^6$ kg) at US\$0.50 lb^{-1} ($\approx$US\$1.1 kg^{-1})] birds caused an estimated loss of US\$$8.5 \times 10^6$.

For a number of years, Mesurol 75% WP (active ingredient methiocarb) proved to be an effective, non-lethal means of controlling bird depredations in blueberries and cherries (Bollengier, Guarino and Stone, 1973; Conover, 1982, 1984; Tobin and Dolbeer, 1987; Dolbeer, Avery and Tobin, 1988). The most recent use pattern for blueberries, designed to limit residues to 5 p.p.m. at harvest, allowed an application of 2.3 kg ha^{-1} with a 7-day preharvest interval. In 1989, however, this registration lapsed when Mobay Corporation, the registrant, declined to meet additional data requirements specified by the US Environmental Protection Agency.

It has been estimated that the cost of meeting the data requirements will be ~US\$$2.6 \times 10^6$ (Fagerstone, Bullard and Ramey, 1990). One approach to addressing the concerns of the EPA is to reduce residues and potential environmental hazards by lowering the application rate. For this approach to succeed, it is first necessary to demonstrate bird repellency at lower application rates.

Personal communications from many blueberry producers indicate that they have achieved good bird repellency using about one-half the formerly labelled rate. Furthermore, satisfactory results were obtained by Stone, Shake and Langowski (1974), who applied methiocarb at 1.5 kg ha^{-1} to blueberries in Michigan. After 14 days, they reported an average loss of 17% from the treated area compared with 44% from untreated bushes.

On the other hand, Schemnitz, Ismail and Gramlich (1976) found no differences in bird damage to blueberries among plots with methiocarb applications of 0,

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1.1 and 2.3 kg ha^{-1}. Dolbeer, Ingram and Stickley (1973) reported that an application of 2.2 kg ha^{-1} was ineffective in reducing bird damage. Teklehaimanot (1978) reported successful reduction in bird damage to blueberries using methiocarb at 1.4 kg ha^{-1}. Interpretation of these results is confounded, however, by the use of malathion with the methiocarb and by the very limited bird use of test plots (3.6% damage to the control, 1.3% to the treated plot).

Thus, the study described here was conducted to determine the effectiveness of methiocarb application rates at ~1.1 kg ha^{-1} and to confirm that residues would be substantially <5 p.p.m. This was approached in a stepwise manner by conducting a replicated aviary trial followed by unreplicated field trials to confirm the aviary results. Successful bird control in one of the initial field trials would initiate a larger-scale replicated field study and provide encouragement to investigate ways to rectify other gaps in the data for registration purposes.

Materials and methods

Aviary trial

Cedar waxwings were mist-netted at the University of Florida Horticulture Unit (UFHU) in May and held in group cages (1.3 × 1.3 × 1.7 m) in an outdoor aviary. They were maintained on a diet of AVN finch-canary feed (Purina Mills, St Louis, MO, USA) with frequent fruit supplements. One week before the trial, 20 waxwings were randomly assigned to four groups (three treatment, one control) of five birds each, moved to an outdoor test aviary and placed in individual cages (1.3 × 1.3 × 1.7 m). These birds received fresh blueberries daily in addition to the maintenance AVN feed.

At the UFHU, Mesurol 75% WP was applied to blueberry bushes using a carbon dioxide-powered hand sprayer calibrated to deliver 75 ml of material in 6 s at a pressure of 275 kPa (40 psi) through a 50-mesh screen and a 8002E nozzle. Methiocarb was applied to eight bushes at 0.6 kg ha^{-1}, to ten at 1.1 kg ha^{-1} and to eight at 1.6 kg ha^{-1}. Each bush was sprayed for 6 s (3 s per side) to deliver the amount of methiocarb calculated to achieve the three application rates (*Table 1*).

Immediately after treatment (day 1) 80 berries were picked from each of the three treatments and from unsprayed control bushes and brought to the field station. Berries were also collected for testing on the mornings of days 3, 5 and 7. In addition, samples of sprayed berries were collected on days 1, 5 and 7 and frozen in foil bags for subsequent residue analyses (Cunningham and Starr, 1973).

On days 1, 3, 5 and 7, each bird was presented with a plastic cup containing 15 berries corresponding to the assigned treatments. Beneath each cage was suspended a plastic collection frame (45 × 45 cm) to catch dropped berries. Each bird also had access to a cup of AVN feed. After 2 h, the number of berries remaining in the cups and the number dropped were recorded for each bird. Total berry consumption (number eaten plus number dropped) was compared among groups and days with two-way repeated measures analysis of variance.

Table 1. Methiocarb applications to blueberry bushes at the University of Florida Horticulture Unit, June 1991[a]

Application rate (kg ha^{-1})	Formulation applied (ml per bush)	Methiocarb applied (mg per bush)	(g l^{-1})
0.6	75	378	5.04
1.1	75	757	10.08
1.6	75	1135	15.12

[a]A planting rate of 320 bushes ha^{-1} and a spray delivery rate of 75 ml (6 s)$^{-1}$ were assumed

Field evaluation

Florida, 1.1 kg ha^{-1}. The University of Florida Horticulture Unit has approximately 3 ha of blueberry cultivars. This area is adjacent to a large tract of woods, and each year from April through July birds cause considerable damage to the blueberries.

For this trial, a nine-row block of bushes was selected, where cedar waxwings had been seen foraging for several days. The rows, approximately 80 m long and 3.8 m apart, contained a mixture of varieties. On 9 May 1991, three adjacent rows (the untreated plot) were sprayed with water using an airblast sprayer calibrated to deliver ~710 l ha^{-1}. The next three rows were unsprayed and served as a buffer. An aqueous solution of methiocarb (Mesurol 75% WP) was then applied at a rate of 1.1 kg ha^{-1} to the next three rows (the treated plot).

Before the spray application, 80 bushes were selected in each treatment and control plot for evaluation, and one branch near the top of each bush was marked with a numbered aluminium tag. For each tagged branch, counting from the tag outward, the total number of berries and the number showing some bluish colour (ripe) were recorded on five occasions: 24 h before spray, immediately after treatment, and 1, 4 and 7 days after spraying. These counts served as the basis for evaluation of the treatment. Throughout, it was assumed that droppage was equal between plots.

Michigan, 1.6 kg ha^{-1}. The Michigan State University Trevor Nichols Research Station blueberry site, located near Fennville, Michigan, was divided into two plots separated by a 13-row buffer zone. Each plot was ~0.2 ha in area and contained between 804 and 816 blueberry bushes. One plot was assigned randomly as a control and the other as treated.

The total number of bushes in the treated and control plots was divided by 80 to derive a uniform bush sampling interval for damage assessment. The location of the first bush was randomly selected within the first sampling interval and subsequent bushes were one interval apart. On each sample bush, a limb with ten ripening blueberries was randomly selected and marked with a numbered metal tag. If the limb held > 10 berries, the excess were removed. The number of berries present on each marked limb was recorded before spraying and 1, 3, 7 and 14 days after spraying. No distinction was made between bird damage and berry drop.

During the prespray assessment, the number of unripe and ripe berries was counted on ten randomly selected limbs in each plot. When berries in each plot approached 50% ripe, the treated plot was sprayed with Mesurol 75% WP at an application rate of 1.6 kg (a.i.) ha^{-1}. An FMC 1029 airblast sprayer calibrated to deliver 465 l ha^{-1} was used to spray the treated plot; the control was not sprayed. Daily precipitation was recorded during the test period.

One 20-g sample of Mesurol 75% WP and a 40-ml sample of spray formulation were collected and frozen before treatment for subsequent verification of chemical concentrations. In addition, 25-g samples of blueberries collected from one randomly chosen location in each plot were pooled by plot and collection period (prespray, postspray 1, 3, 7 and 14 days), labelled, frozen, and stored for residue analysis (Cunningham and Starr, 1973).

Birds were observed at 1, 6 and 12 days before spraying and on days 1, 3 and 7 days after spraying. Observations consisted of recording the number of birds entering each plot for 30 min between 07.00 and 08.00 hours. Observations were made from the same location, which permitted an unobstructed view of each plot without disturbance of any birds present.

Table 2. Analysis of variance of mean blueberry consumption by captive cedar waxwings (n = 5 per group) offered berries[a] treated in the field with methiocarb at rates of 0, 0.6, 1.1 and 1.6 kg ha^{-1}

Source	Degrees of freedom	Sums of squares	Mean squares	F	p
Treatment	3	448.8	149.6	6.1	0.006
Error	16	392.9	24.6		
Day	3	125.5	41.8	11.8	<0.001
Day × treatment	9	57.5	6.4	1.8	0.093
Error	48	170.7	3.6		
Total	79	1195.5			

[a]Berries were presented on the day of treatment and at 2-day intervals after spraying

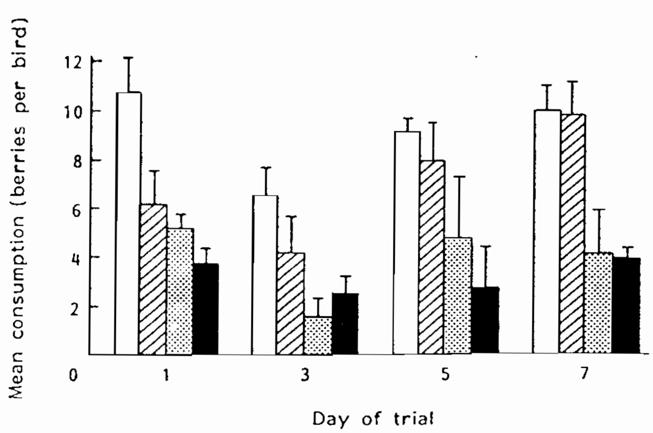

Figure 1. Cedar waxwing consumption of blueberries treated with methiocarb at (□) 0, (▨) 0.6, (▒) 1.1 and (■) 1.6 kg ha^{-1}. Capped bars denote 1 s.e.

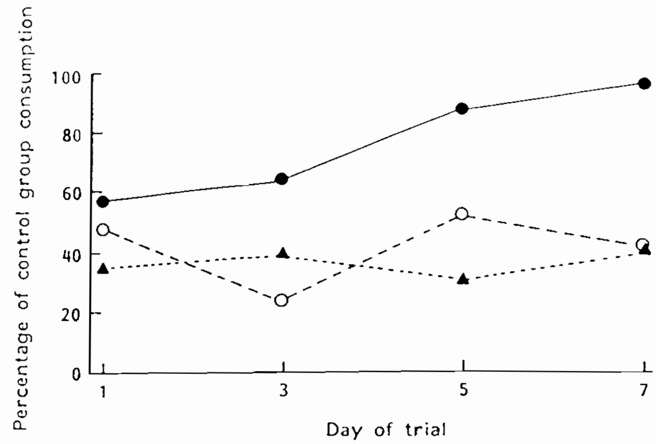

Figure 2. Consumption by cedar waxwings of blueberries treated with (●——●) 0.6, (○– – –○) 1.1 or (▲- - - - -▲) 1.6 kg ha^{-1} methiocarb in relation to the number of untreated berries eaten by a control group

Table 3. Methiocarb residues on blueberries hand-sprayed at the University of Florida Horticulture Unit, June 1991, and harvested at intervals after spraying

Treatment rate		Methiocarb residue (p.p.m.)		
kg ha^{-1}	lb acre^{-1}	Day 1	Day 5	Day 7
0.6	0.5	6.23	1.24	0
1.1	1.0	4.94	0.62	0
1.6	1.5	13.64	1.24	1.24

Results

Aviary trial

Overall, the main effects of treatment level ($p = 0.006$) and day ($p < 0.001$) significantly affected berry consumption (*Table 2*). The day × level interaction was not statistically significant ($p = 0.093$). *Post hoc* analysis revealed that mean berry consumption was suppressed ($p < 0.05$) on day 3 compared with the other days (*Figure 1*). Throughout the trial, mean berry consumption by the control and 0.6 kg ha^{-1} groups were significantly ($p < 0.05$) higher than that in the two other treatment groups. In contrast, consumption by the higher-treatment groups on day 7 was the same as on day 1, at a level ~40% that of the control group (*Figure 2*).

Methiocarb residues on berries collected immediately after the spray treatments ranged up to 13.64 p.p.m. at the highest treatment level (*Table 3*). By day 7, 6 days after spraying, however, residues were below the limits of detection for the 0.6 and 1.1 kg ha^{-1} groups, and only 1.24 p.p.m. in the 1.6 kg ha^{-1} group.

Field evaluation

Florida, 1.1 kg ha^{-1}. One day before treatment, there were 590 berries on the 80 marked control plot branches and 596 on the treated plot branches (*Table 4*). The next day, immediately after spraying, these totals were 552 and 437, respectively. Berry loss continued on both plots throughout the trial (*Figure 3*). At the final count, 7 days after spraying, 389 berries were recorded on the marked control branches and 188 on the sprayed branches (*Table 4*). From 1 h to 7 days after spraying, 29.5% of the berries were lost from control branches compared with 57.0% from the treatment plot.

Michigan, 1.6 kg ha^{-1}. At the time of treatment, 46% of the blueberries showed some degree of ripeness. Crop loss to birds on the treated plot 1 day after spraying was three times greater than on the control plot (*Figure 4*). By days 3 and 7 postspray, however, the damage pattern had been reversed. Overall, blueberry loss to birds at 7 and 14 days after spraying was 59% and 85% on the treated and 65% and 85% on the control, respectively.

The most numerous and frequently recorded birds were American robins (*Turdus migratorius*) and house finches (*Carpodacus mexicanus*). Other species observed were cedar waxwings, American crows (*Corvus brachyrhynchos*), and common grackles (*Quiscalus quiscula*). On day 1 after spraying, the 150 birds observed in the field were distributed equally between the two plots. On days 3 and 7 after spraying, birds on the treated plot represented 39% and 66% of the total number observed, respectively.

Residues on blueberries decreased from 8.56 p.p.m. at 1 day to 1.28 p.p.m. at 14 days after spraying. Over 66% of the decrease occurred between days 3 and 7, coinciding with 1.4 cm of rain recorded on days 4 and 5. Residues decreased from 7.43 p.p.m. on day 3 to 2.47 p.p.m. on day 7 after spraying.

Table 4. Number of blueberries on 80 tagged branches in treatment and control plots relative to the timing of a methiocarb application (1.1 kg a.i. ha^{-1}), University of Florida Horticulture Unit, May 1991

Time of count relative to spraying	Control plot		Treated plot	
	Ripe	Total	Ripe	Total
1 day before	64	590	158	596
1 h after	64	552	72	437
1 day after	82	522	80	376
4 days after	131	459	90	261
7 days after	135	389	92	188

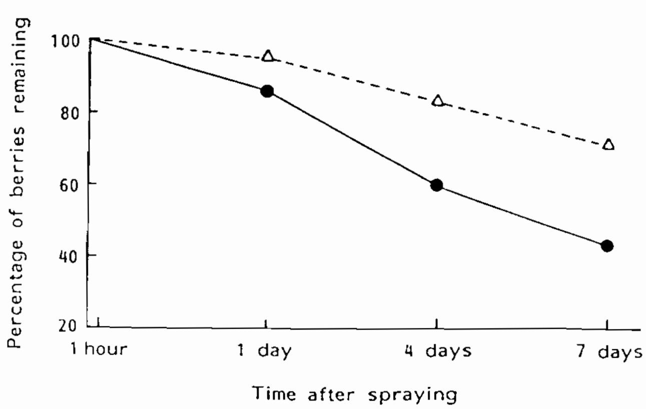

Figure 3. Percentage of blueberries remaining on tagged branches in (●——●) a plot treated with 1.1 kg ha^{-1} methiocarb and (△- - - - -△) in a control plot at intervals after spraying

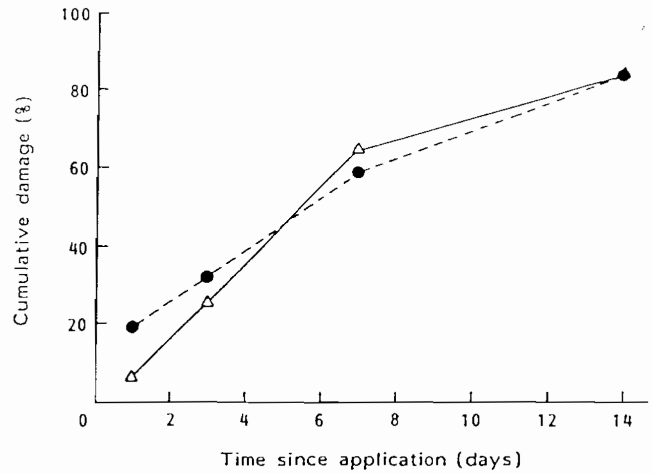

Figure 4. Cumulative loss of blueberries from (●- - - - -●) a plot treated with methiocarb (1.6 kg ha^{-1}) and (△——△) from a control plot at intervals after spraying

Discussion

Choice tests, in cages, of bird repellents are designed to maximize expression of a deterrent effect. The aviary study demonstrated that methiocarb applications of 1.1 and 1.6 kg ha^{-1} reduced cedar waxwing consumption of blueberries by ~60% compared with controls, at least for several days after spraying (*Figure 1*). Although this was a statistically significant result, it did not translate to protection in the field. The unreplicated field evaluation of methiocarb at 1.1 kg ha^{-1} indicated no effect on bird depredations. Similar results were obtained in the evaluation of 1.6 kg ha^{-1} in Michigan.

Several factors may have contributed to the repellency to cedar waxwings of methiocarb-treated blueberries in the aviary trials relative to the field evaluation. First, the spray techniques were different. The airblast sprayers that were used for the field evaluations seemed to blow much of the formulation away from the plants. On the other hand, the hand-held sprayer used in applying methiocarb for the aviary trial was focused directly on the bushes.

Second, the birds in the aviary trial had readily available alternative food so that they could reject the treated fruit without going hungry. The birds in the field may not have had any alternative to blueberries. In northern Florida, the number of wild bird-dispersed plants with ripe fruit is lowest in April and May (Skeate, 1987). Certainly, there were untreated blueberries available, but apparently methiocarb treatments provided little incentive for birds to feed elsewhere in the fields.

Third, the birds in the aviary trial were constant and thus they were able to learn that the berries presented in the cups were not palatable. In the field, it is likely that the composition of the depredating flocks changed during the trials. If so, then new, untrained birds would have to learn where to forage. The learning takes time, during which berry loss accumulates.

Fourth, singly caged birds were tested. Many avian depredators in the field are flock-foragers. The social interactions within the feeding flock may cause more persistent use of a methiocarb-treated areas than would occur in single birds.

The residue analyses from the aviary trial and the Michigan field study were substantially lower than the previous 5 p.p.m. limit. Although this is encouraging, the poor deterrence of the treatments in the field may make the residue levels irrelevant.

Management implications

Although Mesurol has been used successfully in the past as a bird repellent in blueberries and other small fruit, there are major impediments for its use in the future (Tobin and Dolbeer, 1987). The results showed that methiocarb application rates in the range 0.6–1.6 kg ha^{-1} will produce residues of approximately 1–2 p.p.m. at harvest, which is a substantial reduction from the previous 5 p.p.m. level of tolerance. Unfortunately, these same studies failed to produce evidence that the lower application rates repelled birds. Thus, these results do not support efficacy claims for single methiocarb applications of 0.6–1.6 kg ha^{-1}.

Even had the reduced rates of methiocarb resulted in satisfactory control of bird depredations, numerous data requirements remain to be met before registration would be possible. It is not clear where the millions of dollars needed to provide the necessary data would come from.

Rather than attempt to resurrect methiocarb as a bird repellent on fruit, it might be appropriate to direct resources toward the development of alternative methods. In the short term, alternative repellent materials should be screened, tested and evaluated (e.g. Askham, 1992; Avery, 1992). Other candidate materials might include pesticides currently registered for blueberries that also appear to possess some bird-repellent properties (e.g. phosmet: Avery and Nol, 1991).

A longer-term approach involves the development of blueberry cultivars not preferred by birds. In particular, because species such as the European starling (*Sturnus vulgaris*) and American robin are physiologically incapable of digesting sucrose (Martinez del Rio *et al.*, 1988; Karasov and Levey, 1990), the development of high-sucrose blueberry cultivars may be another means of reducing damage by avian frugivores (Brugger and Nelms, 1991).

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